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A STUDY OF WATER SUPPLY FOR BUDGET PURPOSES

By William W. Brush

Money for carrying on the public works of the city of New York is appropriated by a budget system. The various departments submit detailed estimates of the sums they desire and the reasons for requesting this money at the time, and the appropriations are made, or not made, for these items by the officials in charge of the city's finances. The operation of the water works of the city calls for a very large appropriation and as various alternative sources of supply are available for parts of Greater New York, the engineering recommendations regarding the budget must be based on a variety of factors which have little significance in cities supplied from a single source.

Sources of supply. The city is supplied from five systems, (1) the Catskill; (2) the Croton; (3) the Brooklyn; (4) the Queens; (5) the Richmond.

The Esopus watershed on the Catskill system has an area of 257 square miles and during a succession of very dry years such as occur once or twice in a century it will probably yield 250,000,000 gallons daily. The records from 1907 to 1917 inclusive indicate that it would have been safe to count on 375,000,000 gallons daily. The Ashokan reservoir in which the runoff of this watershed is impounded holds 127,000,000,000 gallons and on June 1, 1918, there was stored in it 113,602,000,000 gallons.

The Catskill aqueduct leading from the Ashokan reservoir to the Kensico reservoir has a capacity at present of 375,000,000 gallons daily. It is a mere coincidence that this capacity is the same quantity as the average runoff of the Esopus watershed in recent years. From the Kensico reservoir to the Hillview reservoir the Catskill aqueduct has a capacity of about 500,000,000 gallons daily.

The Kensico reservoir has a watershed of 22 square miles and during a year of average rainfall this watershed will furnish about 20,000,000 gallons daily. If there is neither increase nor decrease in the amount of water stored in the Kensico reservoir, there is thus available at the outlet of the reservoir about 395,000,000 gallons daily under average conditions. The reservoir holds 29,200,000,000 gallons and was constructed to provide a reserve supply near the city in case of emergency or when it is necessary to shut down the Catskill aqueduct leading to it from the Ashokan reservoir. It should be full each spring, but the abnormally heavy draft during the winter of 1917–1918, due to protracted, very cold weather, depleted the quantity of stored water somewhat. If the reservoir is to be full on December 31, 1919, about 12,000,000 gallons daily must be added to it, using the condition of the reservoir in the early summer of 1918 as a basis of the estimate, and if this storing of water is done the available supply from the reservoir while this is going on is not over 383,000,000 gallons daily.

The Croton watershed with the existing reservoirs has a safe minimum runoff of 336,000,000 gallons daily and an average runoff of a little more than 400,000,000 gallons daily. The old and new Croton aqueducts have a combined capacity of about 390,000,000 gallons daily. During the early part of the summer of 1918 the draft on this system was about 190,000,000 gallons daily.

The Brooklyn system has a normal yield of about 150,000,000 gallons daily. No water has been drawn from it since early in 1917 but the system can be put in operation again at any time. The Queens system consists of two small plants with a combined yield of 6,000,000 gallons daily. They are not in service now but can be made ready for operation in a short time. The Richmond system comprises six small plants with a combined capacity of about 14,000-000 gallons daily. These are now being held in reserve.

The total capacity of the water works of New York is, therefore, about 955,000,000 gallons daily, and in June, 1918, only 63 per cent of this was being used, namely, 412,000,000 gallons from the Catskill system 5,000,000 gallons from local sources and 190,000,000 gallons from the Croton system.

Consumption. Studies of the consumption during 1917 and 1918 indicate that if no change is made in the pressures and no special measures to check water waste are taken in 1919 the average consumption during the first half of the year in the districts now supplied with Catskill water will be 442,000,000 gallons and during the last half 454,800,000 gallons daily, while in the districts now supplied with Croton water the average draft will be 194,000,000 gallons daily during the first half of the year and 200,200,000 gallons daily after that. The average for the entire city and year is estimated at 645,500,000 gallons daily. If a change is made in the districts supplied with Catskill water, if more measures are taken to check waste or if weather conditions are abnormal, these estimates of the draft during the current year will of course be inaccurate. The amount of water stated is considered a minimum and must be provided if the conditions during the year are as assumed.

In February, 1917, the Department of Water Supply, Gas and Electricity issued a circular stating that as rapidly as possible the new Catskill supply would be introduced in districts of which the boundaries were described. This supply is under considerably higher pressure than the Croton supply then in use, and householders were advised to have their plumbing overhauled to meet the new pressure conditions. In thousands of buildings pumps were then in use to force water to the upper stories, or large tanks at the top of the buildings were allowed to fill slowly during the night, when the normal use of water was small, and serve as reserve sources of supply for the daytime demands. Such service was unsatisfactory and it was considered desirable to furnish Catskill water under sufficient pressure to force it to the top story of the normal type of building in the district where the pressure conditions were worst. This proposed increase in pressure has been carried out only in part. About 29,000,000 gallons daily were furnished during last summer in this district from the Croton supply and about 15,000,000 gallons from the Catskill supply delivered against Croton pressure to raise the Croton's hydraulic gradient in lower Manhattan. The only way to give the desired increase in pressure throughout this district is to pump the Croton supply or replace it by Catskill water. If such a change in pressure is made by either of the possible methods it must be carried out slowly in order that the distribution system as well as the plumbing in private premises may be prepared for it.

From what has been stated it is evident that New York has a large surplus of water available for several years to come. The business problem is whether it is better to furnish more water as the demands increase or to carry out a careful inspection of all premises receiving unmetered water, and what pressure shall be used. These features of the administration of the department were studied and the following conclusions were reached in June, 1918:

A gradually increasing reduction in the waste of water, reaching a maximum of 83,000,000 gallons daily at the end of a year's work may be obtained through employing 126 inspectors and clerks to examine all the unmetered premises supplied with Catskill or pumped Croton water. This work was estimated to cost about $130,000 and if continued for eighteen months $195,000. In this way the depletion of the Kensico reservoir would be ended by the close of 1919 and enough Catskill water would be available to permit its extension into the areas where it had been promised but not delivered or to reduce considerably, the pumping of Croton water. The cost of this waste reduction would be about $5.92 per million gallons up to the close of 1919 and about $4.29 after that date.

Another method of meeting the business problem would be to operate additional pumping stations so as to furnish more water under adequate pressures for the buildings of normal height. About 30,000,000 gallons a day would have to be pumped at the Jerome Avenue Station in the Bronx and about 31,000,000 gallons at the Brooklyn stations. This would cost about $12.23 per million gallons, nearly three times the expense of accomplishing the same purpose by waste prevention measures of a thorough sort.

Another method of meeting the situation would be to replace the Catskill supply furnished under a pressure of about 45 pounds, on an average, with the Croton supply under a pressure of about 26 pounds. This would make it necessary to begin pumping in the houses again, and while it would reduce the consumption of water it would be an unpopular method. The adoption of a thorough system of waste prevention by inspection of unmetered premises was recommended as the best method of meeting the conditions which were anticipated.

The statements made in the preceding portion of this paper give an outline of the water supply conditions of New York in June, 1918, and a knowledge of these conditions is desirable for a study of the economic problem of whether any provision should be made in the 1919 budget for additional pumping, when the need for such provision depends upon the rainfall and runoff in the Catskill watershed during that year being below the average.

Should the budget provide for additional pumping? It has already been stated that the capacity of the Catskill aqueduct from Ashokan reservoir to Kensico reservoir is 375,000,000 gallons daily, and the 1919 budget is based on the continuance of a draft of about this quantity from the watershed. It also provides for a continuance of a local supply of about 5,000,000 gallons daily from two of the pumping stations on Staten Island, furnishing water to the Borough of Richmond.

During the years 1907 to 1917 inclusive the smallest runoff, corrected for the present reservoir conditions, was 322,000,000 gallons daily and the largest runoff was 427,000,000 gallons daily, the average being 379,000,000 gallons daily. If the reservoir had been full in the spring of 1907 it would have been possible to maintain a draft of 375,000,000 gallons daily from that date to the beginning of 1919 without reducing at any time the quantity of water stored below 34,000,000 gallons this being 25 per cent of the full capacity. It should be noticed, however, that this draft of 375,000,000 gallons is about 125,000,000 gallons daily above the runoff of the Catskill watershed if the latter experiences a series of dry years such as produced minimum runoff conditions on the Croton watershed in 1880. If the city had no other available sources of supply it would be hazardous to exceed materially a draft of 250,000,000 gallons from the Ashokan reservoir, but as there are large substitute supplies it is safe to continue the draft of 375,000,000 gallons so long as the water is available, bearing in mind always that this draft is 50 per cent greater than the safe mimimum supply based on the runoff data of the Croton watershed.

Although many men have studied exhaustively the rainfall records in various parts of this country and Europe, they have been unable to determine any law which will permit a fairly accurate estimate to be made of the amount of future rainfall in a year. In 1903 this section of the country experienced a rainfall of about 9 inches within twenty-four hours. This exceeds the normal rainfall in sixty days. Such a rainfall on the Catskill watershed would be equivalent to 36,000,000,000 gallons runoff, or enough to maintain the rate of draft in the fall of 1918 for a period of three months.

The Catskill water is delivered to the city under a head equivalent to an elevation of 295 feet above sea level, sufficient to permit a gravity delivery to nearly all of Manhattan, all of the Bronx and Brooklyn, and all but a very small part of the remaining two boroughs. Within the areas where the ground is too high for the direct Catskill pressure the consumption is only about 10,000,000 gallons daily. Before the introduction of this supply the city was operating 42 pumping stations at an annual cost of about $1,500,000. This cost would be increased 50 per cent today, on account of the

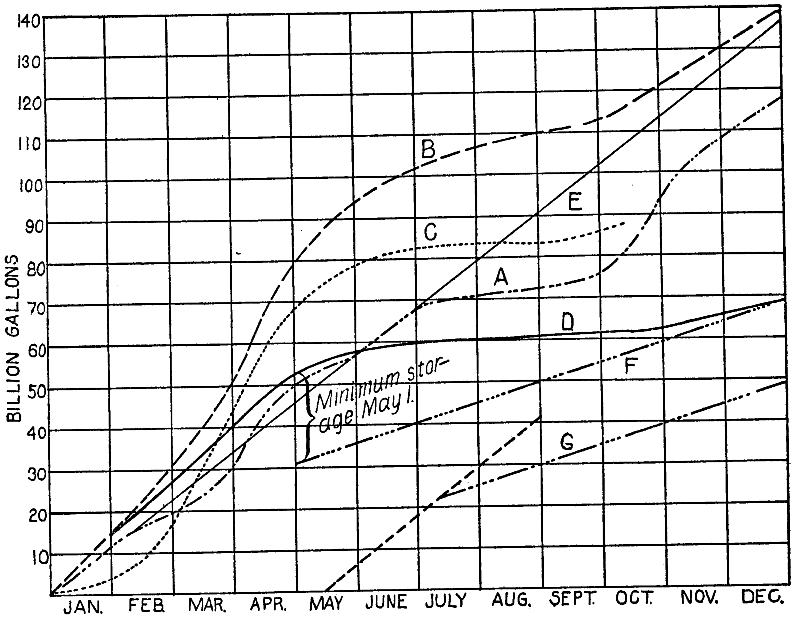

FIG. 1. RUNOFF AND DRAFT CURVES FOR THE CATSKILL (ESOPUS) WATERSHED

A, Runoff from the Catskill (Esopus) watershed for the driest year since 1907, which was 1911.

B, The average runoff from 1907 through 1917.

C, The runoff for 1918.

D, The estimated runoff assuming the low runoff conditions which occurred on the Croton watershed in 1880.

E, Draft line for 375,000,000 gallons daily.

F, Draft line for 156,000,000 gallons daily, which is the difference between a draft of 375,000,000 gallons daily and a possible additional pumpage of 219,000000 gallons daily.

G, Draft line assuming a storage of 51,000,000,000 gallons on January 1, 1919, and a draft of 375,000,000 gallons daily.

Note: 138,400,000,000 gallons yearly = 379,000,000 gallons daily
136,700,000,000 gallons yearly = 375,000,000 gallons daily
80,000,000,000 gallons yearly = 219,000,000 gallons daily
57,000,000,000 gallons yearly = 156,000,000 gallons daily

increased cost of supplies and labor. There are now five pumping stations regularly operating; thirteen have been partly dismantled and boarded up. The remainder have skeleton crews and are ready for operation in emergencies, in most cases. Assuming that the draft of Catskill water is reduced to the estimated minimum safe supply of 250,000,000 gallons daily, it would be necessary to pump about 125,000,000 gallons daily, which would entail an annual additional expense of about $1,000,000. If any part or the whole of such pumping can be avoided by a draft on the Catskill supply, this should be maintained up to the point where its continuance will jeopardize the sufficiency of the water supply of the future.

Attention is called to figure 1, showing the runoff and draft from the Catskill watershed. It will be seen that the draft line of 375,000,000 gallons daily is within the average runoff curve but the draft line cuts through the 1918 runoff curve in August. If during 1919 there should be a runoff as low as that based on the 1880 Croton runoff, it would be necessary to start full operation of all pumping stations in July in order to retain 20,000,000,000 gallons in the Ashokan reservoir at the close of the year. This quantity is the smallest amount of reserve stored water with which the city should be content. The operation of all the pumping stations would furnish about 219,000,000 gallons daily in excess of the present yield and, on the basis of present prices, would increase the department's expenses above those used in the budget by about $150,000 per month. It seems unnecessary to request a budget appropriation to meet such a contingency, which, if it arises, is better classed as a foreseen but unlikely emergency. The provision of sums to meet these unlikely conditions would swell appropriations above the amount which experience shows to be necessary. It is much better to point out to the city's financial authorities that under exceptional conditions a decided increase over the budget requests may be necessary than to make such requests with the knowledge that probably the increased sums will not be needed.